The Sick Building Syndrome: Where Is the Epidemiologic Basis?

Indoor air quality complaints from office workers first came to the attention of public health authorities at county, state, and federal levels approximately 15 years ago. Investigations of office environments associated with widespread reports of headache, fatigue, and mucous membrane complaints did not usually identify single air contaminants at levels which could account for the symptoms. In the absence of an explanation in the traditional industrial hygiene conceptual framework, many investigators ascribed the complaints to mass psychogenic illness. However, the remarkable consistency of such complaints occurring in sealed buildings all over the country, paired with their chronic nature, discredited such diagnoses by exclusion and demanded a new conceptual framework.

The next predominant explanation invoked for these "sick building syndrome" complaints was inadequate fresh air intake in mechanically ventilated buildings. This hypothesis remained untested, despite recommendations from the National Institute for Occupational Safety and Health (NIOSH) that carbon dioxide levels be kept below 1,000 parts per million. No follow-up or experimental studies were performed in problem buildings to determine whether increasing the ventilation rates alleviated complaints. More important, no epidemiologic studies of buildings and their occupants were undertaken in the United States, apart from investigations precipitated by complaints.

European epidemiologic studies[1–3] of building-related complaints provided new conceptual frameworks for indoor air quality. In buildings studied without regard to known complaints in both Great Britain and Denmark, the rates of work-related symptoms varied substantially but were common. The presence of mechanical ventilation and air changes per hour were less important than the type of air conditioning, with the moisture common to humidification and chilling systems being associated with high complaint rates. Work organization, job category, and gender were associated with the perception of work-related symptoms independent of class of ventilation. Occupant activities and the building furnishing parameters were associated with indoor air quality complaint rates.

Reanalysis of these European studies as reported by Mendell and Smith[4] in this issue of the Journal is extremely helpful, since the apparent inconsistencies among these studies have partially disappeared with a uniform classification of type of ventilation and with prevalence odds ratios of symptoms for pooled populations in each ventilation category. The association of sealed, air-conditioned buildings with higher prevalences of work-related headache, lethargy, and mucous membrane irritation is not surprising, since these are the buildings in the US generating the complaints. However, the presence of elevated complaint rates in sealed buildings which have not come to public health attention underscores the broad importance of understanding the determinants of health and comfort in air conditioned buildings.

In addition to the symptom surveys reanalyzed by Mendell and Smith,[4] European investigators have published exciting work on sources of pollution in office buildings using trained human panels.[5,6] In Denmark, 54 air quality judges assessed acceptability of air quality, odor, and stuffiness in 20 randomly selected offices and assembly halls when the buildings were unoccupied, with and without mechanical ventilation, and when occupied with mechanical ventilation. Pollution sources from building and furnishing materials, the ventilation system, and smoking each outweighed the deterioration in air quality derived from occupants alone. "Overventilation" on the basis of standards which exist to control body odor from human occupancy did not prevent a judgment of unacceptable indoor air quality by 36 percent of judges. Large variations in average perceived air quality were not associated with ventilation rates, carbon dioxide, particulates, or volatile organic compounds. Although higher air change rates tended to result in higher satisfaction rates, the operation of mechanical ventilation increased the dissatisfaction with air quality in some buildings, implying that the ventilation system itself contributes substantially to poor indoor air quality in some buildings. Since some buildings had little contribution from building furnishings or materials or from the ventilation system, the possibility exists for prevention of perceived poor indoor air quality by attention to these pollution sources. Remedial and preventive action must be tailored to the control of pollution from its sources. Carbon dioxide measurements are limited as an indicator of acceptable ventilation, since carbon dioxide has a human source and will not reflect perceived air pollution from furnishings or ventilation sources.

The prevalence of sick building syndrome in the United States is unknown, as is the proportion of buildings with elevated complaint rates. The best estimate of the magnitude of the problem is a nationwide, random stratified sample of office workers conducted by Honeywell Technalysis, which found that 24 percent of 600 office workers perceived air quality problems to exist in their office environments.[7] Seven to 11 percent of the Honeywell sample reported that the following individual complaints were a very serious or somewhat serious problem: a tired feeling, congested nose, eye irritations, headaches, or difficulty in breathing. Twenty percent of all respondents perceived their work performance to be hampered by the air quality.[8] Woods has estimated that 800,000 to 1,200,000 commercial buildings in the United States have problems that manifest as sick building syndrome, with 30–70 million exposed occupants.[8] He has pointed out that the relative cost of a 25 percent energy savings in building operation is outweighed by the loss of 2 to 6 minutes per person-day of productive concentration.

Indoor air quality concerns are not limited to the discomfort complaints of sick building syndrome. Building-related illnesses, distinguished by objective findings underlying pathologic diagnoses, include hypersensitivity, pneumonitis, asthma, and infections such as legionellosis.[9,10] These are frequently related to humidification systems or other components of temperature control. Building-related illness occurs in settings which also have high complaint rates of symptoms consistent with sick building syndrome.[8] Whether this coincidence points to a common source is unclear.

Building and ventilation design characteristics may have major public health implications for transmission of communicable disease as well. Investigators in Switzerland found increased absenteeism for respiratory illness in a fully air conditioned building, in comparison to a naturally ventilated building with a similar population.[11] A US Army study showed a 51 percent increase in febrile acute respiratory disease in basic trainees at four army centers living in

energy-efficient army barracks in comparison to trainees living in old "leaky" barracks. Higher increases to 250 percent were documented in the residents of "tight" barracks during epidemic years when trainees were not immunized against adenovirus infection. Rates of respiratory disease increased as training progressed in the modern barracks in comparison to old barracks, consistent with more efficient transmission of respiratory pathogens.[12]

Considerable resources have been applied in both public and private sectors in response to complaints from office workers. NIOSH has conducted more than 1,000 hazard evaluations in response to indoor air quality complaints, which constitute the most frequent request for assistance. Consultant firms concentrating on indoor air quality remediation are flourishing. However, no significant federal monies for or efforts toward research on indoor air quality have existed to develop the scientific underpinnings for remediation and prevention of indoor air quality complaints. Agency efforts largely remain limited to nonepidemiologic approaches initiated by single disciplines.

The scientific underpinnings for solving indoor air quality complaints will only be established by systematic epidemiologic work in conjunction with ventilation engineering and industrial hygiene assessment. The first order of the research agenda is to confirm in this country the epidemiologic findings from the reanalysis by Mendell and Smith by studying a stratified random sample of buildings and their occupants. Attempts to standardize questionnaires among investigators seem unnecessary, if results are reported using prevalence odds ratios. Whether bioaerosols can be implicated in sick building syndrome requires systematic investigation with sampling and identification techniques that are not widely available and have major methodologic problems.[13] Research on infection transmission rates in relation to building and ventilation design is critical, given the staggering public health and economic implications. Our understanding of indoor air quality effects on health will increase only when we study what parameters of buildings, their furnishings, and their ventilation systems are associated with healthy, happy occupants.

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